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Studies on the Effect of Phosphorus from Organic Manures on Soil Phosphorus, Yield and Quality of Groundnut

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ABSTRACT

Potculture experiment was conducted to study the effect of different sources of phosphorus on soil phosphorus availability, uptake, yield and quality of groundnut. Four organic sources (farmyard manure, poultry manure, vermicompost and sewage sludge) were evaluated in comparison with single super phosphate, all applied on equal P basis @ 34 kg P_2O_5 ha^{-1}. The six treatments, including a no-P as control were replicated four times in a completely randomized design. The results revealed that the addition of phosphorus markedly increased the phosphorus uptake and thereby increased the pod yield. Among the sources poultry manure recorded the highest yield 0.4 g pot^{-1} and was followed by farmyard manure 37.1 g pot^{-1}. Phosphorus sources significantly increased the oil content but no significant impact among sources. Phosphorus application significantly increased the crude protein percentage. Among sources, crude protein content was higher in poultry manure treatment (12.83). Highest available phosphorus content was recorded in poultry manure treated soil (28.5 kg ha^{-1}) and Farmyard manure was the second best source of available phosphorus.

Introduction

Oilseeds are energy rich crops and their nutrient requirement is high (Hegde, 2000). Despite the high nutrient requirement, they are mostly grown under energy-starved conditions. Low or no use of plant nutrients is one of the most important factors for low productivity of oilseeds. The estimated nutrient removal by oilseeds crop during 2003–2004 was 3.24 million tonnes (N, P and K), while the contribution to nutrient uptake from fertilizer was only 15.4 per cent (Hegde, 2006).

Soil fertility cannot be maintained with the application of inorganic fertilizers alone. Besides inorganic chemical fertilizers, there are several sources of plant nutrients like organic manures, crop residues, and industrial wastes. No single source can meet the increasing nutrient demands for agriculture. To achieve sustainability in production, there is a need to integrate both organic and inorganic sources of nutrients. Before integrating nutrient sources, it is necessary to workout and quantify fertilizer replacement value of different organic sources. Such an integration of nutrient sources will enhance the nutritional use efficiencies (Hegde and Sudhakarababu, 2001) besides maintaining soil fertility. There is a need to workout the region specific nutrient supply packages by integrating all the available sources of nutrients.

Phosphorus can be termed as “life mineral” because of its crucial role in metabolic and energy transfer reactions in living systems. Phosphorus has a great role in energy storage and transfer and as a constituent of nucleic acid, phytin and phospholipids in plants. An adequate supply of phosphorus early in plant life is important for the reproductive parts of the plants. It plays an essential role in carbohydrate metabolism, fat metabolism and also in respiration of plants. Phosphorus deficiency is common in almost all the soils and crops in different regions of the country.

The availability of phosphate in soils is often limited by fixation reactions, which convert the monophosphate ion to various insoluble forms. The availability of soil phosphate is enhanced by the addition of organic manures, presumably due to chelation of polyvalent cations by organic acids and other decay products. Varalakshmi *et al*., (2005) demonstrated that incorporation of farm yard manure along with inorganic phosphorus increases the availability of phosphorus and this is attributable to reduction in fixation of water soluble phosphorus, increased mineralization of organic phosphorus due to microbial action and enhanced mobility of phosphorus.

Groundnut, is an important oilseed and food crop as its seeds are a rich source of edible oil (43-55%) and protein (25-28%). Information on the exact quantity of phosphorus rendered available to crops from the applied manures is scanty. Against this backdrop, an investigation was carried out to study the uptake of phosphorus and quality of produce in groundnut consequent to the application of organic manures.

Materials and method

The soil used in the present study was loamy sand in texture and it contained 15.5, 6.5 and 78.0 percent clay, silt and sand respectively. The contents of available N, P, K were 950.3, 31.51 and 693.3 mg kg^{-1} respectively and the organic carbon content was 6.3 g kg^{-1}. The total phosphorus content of organic manures used was 1.12, 3.80, 0.94 and 1.81 percent in farmyard manure, poultry manure, vermicompost and sewage sludge respectively.

The processed soil samples (The bulk soil collected was air-dried in shade, gently pounded with a wooden mallet and sieved to pass through a 2mm sieve) were filled in earthen pots at the rate of 8 kg soil per pot. There were four organic sources (farmyard manure, poultry manure, vermicompost

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and sewage sludge) evaluated in comparison with inorganic sources of single superphosphate. All the organic sources mixed with soil and applied on equal P basis at the rate of 34 kg P_2O_5 ha^{-1}(0.054g P/8 kg soil). The six treatments, including a no-P (control) were replicated four times in a completely randomized design making a total of 24 pots.

Seeds of groundnut (five per pot) were sown in each pot. To all the pots, common basal applications of 17 kg N ha^{-1} as urea, 54 kg K_2O ha^{-1} as muriate of potash and 74.34 kg S ha^{-1} as gypsum were given. Routine cultural practices were adopted in raising the crop. Hundred and five days after sowing pods were harvested and pods from each pot were weighed and total yield was expressed in kg ha^{-1}. Oven dried kernel were chopped and ground in a Wiley mill and stored. The plant materials were analyzed for P. Triple acid (9:2:1 HNO_3: H_2SO_4: $HClO_4$) digestion was followed for phosphorus analysis by using Vanado molybdo phosphoric acid yellow colour method (Jackson, 1973). From the phosphorus content and dry matter yield of groundnut phosphorus uptake was calculated and expressed in g pot^{-1}.

The oil content in the kernels was determined by Soxhlet extraction using petroleum ether (Boiling point 40 – 60 ºC) as solvent as per the standard AOAC procedure (Horowitz, 1984). Protein content of kernel was estimated by multiplying nitrogen content (%) of kernel with 5.46. For peanut, a factor of **5.46** is used for converting nitrogen concentration into protein concentration because the peanut proteins arachin and conarachin contain **18.31**% nitrogen (Misra. 2001).

Statistical analysis

The data obtained from the above investigations were subjected to SAS statistical analysis to find out the effect of various treatments on the availability of nutrients, nutrient contents of groundnut

Results and Discussion

Soil available phosphorus content

The results pertaining to the available phosphorus content in post-harvest soils indicated that the phosphorus application through different sources significantly increased the available phosphorus content in soil. Phosphorus availability increased significantly from 10.9 kg ha^{-1} under control to 25.2 kg ha^{-1} with farmyard manure application and to 28.5 kg ha^{-1} with poultry manure after the harvest of groundnut.

Organic acids and chelates are produced during microbial decomposition of organic residues. These organic acids help in the solubility of native phosphorus as a result of which increase in available phosphorus content. It was confirmed by Tasdo *et al.*, (2014). Applied organic manure leads to the formation of coating on the sesquioxides because of which the phosphorus fixing capacity of soil was reduced in manure treated plots in groundnut (Reddy, 2005). Siddque and Robinson (2003) confirmed the decreases in soil phosphorus sorption characteristics following the application of animal manures and effluents.

The highest available phosphorus content was recorded in poultry manure treated soil. Poultry manure is rich organic manure since solid and liquid excreta are excreted together resulting in no urine loss (Amanullah *et al.*, 2007). Farmyard manure was the second best source. In a study on the impact of FYM and poultry manure on P availability, Rao (2003) observed that the available P content in soil increased significantly from 19.5 kg ha^{-1} under control to 20.8 and 21.5 kg ha^{-1} with 10t FYM and 5t poultry manure ha^{-1}, respectively. Among organic sources vermicompost recorded the lowest value (17.5 kg ha^{-1}).

But it was significantly superior to superphosphate treatment. This may washed down from the soil easily.

Table 1. Effect of phosphorus sources on post-harvest soil phosphorus availability.

Phosphorus sources	Available P (kg ha^{-1})
Control	10.9e
Farmyard manure	25.2b
Poultry manure	28.5a
Vermicompost	17.5d
Sewage sludge	22.2c
Superphosphate	15.0d

Yield

Application of phosphorus through different sources out yielded significantly the control, in cases of pod yield and kernel weight. This is in agreement with the results obtained by Karikari *et al.* (2015) that, Phosphorus fertilizer significantly increased vegetative growth, nodulation and its resultant seed yield. An adequate supply of phosphorus has been associated historically with increased root growth, which in turn resulted in better uptake of nutrients and water in the development of nodules. This could be a possible explanation for increase in yield with phosphorus application. This was supported by Singh *et al* (2005).

Agarwal *et al.* (2007) emphasized that phosphorus helps in the formation of more nodules, more vigorous root development, better nitrogen fixation and overall better development of plants. Kumar *et al.* (2006) also reported that phosphorus is important in root development and translocation of photosynthates. Being a constituent of nucleic acids, phytin and phospholipids, phosphorus application increased growth and yield attributing parameters.

The pod yield data revealed that poultry manure markedly increased the pod yield to 40.4 g pot^{-1}. Among the organic sources poultry manure significantly increased the kernel yield to 32.6 g pot^{-1}. This might be due to the availability of all essential macro- and micronutrients which are necessary for improving quality. Poultry manure in this regard occupies the pride of place as it is rich in nutrients than the other manures (Amanulla *et al.*, 2007). Therefore, it supplemented all the nutrients to groundnut, thereby boosting up not only the yield of groundnut but improving its quality also.

Table 2. Effect of phosphorus sources on groundnut yield (g pot^{-1}).

Phosphorus sources	Pod yield (g pot^{-1})	Kernel (g pot^{-1})
Control	23.4e	13.7e
Farmyard manure	37.1b	25.2b
Poultry manure	40.4a	32.6a
Vermicompost	29.5d	21.2c
Sewage sludge	32.0c	22.7bc
Superphosphate	30.0d	18.6d

Plant phosphorus content and uptake

The nutrient content and uptake varied significantly among treatments. The uptake of nutrients increased with increasing doses and availability of nutrients. Increase in uptake of nutrients might be due to the increased accumulation of dry matter. This study indicated a positive correlation between yield and phosphorus uptake. This was confirmed by Singh *et al.*, (2005) that the application of P significantly increased the seed yield, nodule number, root length and its dry weight.

The manure treatments might have improved the soil environment, encouraged root proliferation and root surface absorption zone, which, in turn, would have drawn more water and nutrients. Chng (2015) indicated that organic amendments increased phosphorus availability in soil also improved nutrients uptake and dry matter production of *Zea mays*.

The higher nutrient uptake with organic manures and single super phosphate was due to that the plants being able to absorb more nutrients from the soil because of their increased availability due to improved soil conditions. This result might be well supported by the findings of Kedar Prasad *et al.* (2005) in maize wheat sequence. Among the treatments, poultry manure enhanced the phosphorus uptake over control, recording value of 115.9 mg pot^{-1}. The probable reason for getting higher nutrient contents with the addition of poultry manure might be the increased release of macro- as well as micronutrients in soil, resulting in better extraction of nutrients by the crop. Thyagarajan., *et al* (2013) stated that poultry manure is used as a very good source of fertilizer

Table 3. Effect of phosphorus sources on plant phosphorus content and uptake.

Phosphorus sources	Content (%)	Uptake (mg pot^{-1})
Control	0.19d	27.1e
Farmyard manure	0.29b	75.1b
Poultry manure	0.35a	115.9a
Vermicompost	0.27b	57.9c
Sewage sludge	0.27b	60.3c
Superphosphate	0.23c	41.9d

Groundnut quality

The oil content in kernel was significantly influenced by phosphorus application. Phosphorus is known to be directly responsible for oil and albumin synthesis. The findings of the present investigation are in conformity with the findings of Zakaria *et al.* (2006). Phosphorus also helped in synthesis of fatty acids and their esterification by accelerating biochemical reactions in glyoxalate cycle. The different sources did not significantly influence the oil content.

The results revealed that protein content increased with the addition of phosphorus levels. Among phosphorus sources, poultry manure recorded the highest crude protein content of 12.83 % and it might be attributed to the efficient assimilation of reduced nitrogen to aminoacids and protein. Magani and Kuchinda (2006) confirmed that the phosphorus application leads to an improvement in the protein content in cowpea.

Table 4.Effect of phosphorus sources on quality of groundnut.

Phosphorus sources	Oil content (%)	Protein content (%)
Control	31.1b	6.65e
Farmyard manure	33.0a	12.34b
Poultry manure	34.1a	12.83a
Vermicompost	33.1a	11.82c
Sewage sludge	33.2a	12.60a
Superphosphate	33.4a	10.39d

Conclusion

The results revealed that poultry manure markedly increased the pod yield to 40.4 g pot^{-1} and was followed by farmyard manure 37.1 g pot^{-1}.Different P sources did not show any significant impact on oil content in groundnut, but was significantly higher than control. Phosphorus application significantly increased the crude protein percentage. Among phosphorus sources, poultry manure recorded the highest crude protein of 12.83%. Phosphorus application through different sources increased the phosphorus content in soil from 10.9 (control) to 28.5 kg ha^{-1} after the harvest of groundnut. Among the sources tested the highest phosphorus content was recorded in poultry manure treated soil. Farmyard manure was the second best source. Poultry manure enhanced the phosphorus uptake over control.

From this potculture experiment it can be concluded that the parameters tested postharvest soil available phosphorus, yield attributes; pod yield and kernel yield and quality parameter; crude protein content were significantly increased by phosphorus sources. Among the sources, the effect of poultry manure was foremost.

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